UNCLASSIFIED

| AD NUMBER |
|---|
| AD014009 |
| NEW LIMITATION CHANGE |
| TO<br>Approved for public release, distribution unlimited |
| FROM<br>Distribution No Foreign |
| AUTHORITY |
| afal ltr, 17 aug 79 |

THIS PAGE IS UNCLASSIFIED

TI-856

23 July 53

WADC TECHNICAL REPORT 52-239

# RF OSCILLATOR O-(XA-5)/U


*WILLIAM S. DWINELL*
*COMMUNICATION AND NAVIGATION LABORATORY*


*SEPTEMBER 1952*

WRIGHT AIR DEVELOPMENT CENTER

20010501010


AF-WP-(B)-O-17 JUL 53 50

## NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The information furnished herewith is made available for study upon the understanding that the Government's proprietary interests in and relating thereto shall not be impaired. It is desired that the Judge Advocate (WCJ), Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, be promptly notified of any apparent conflict between the Government's proprietary interests and those of others.

WADC TECHNICAL REPORT 52-239

# RF OSCILLATOR O-(XA-5)/U

*William S. Dwinell*
*Communication and Navigation Laboratory*

*September 1952*

*RDO No. 102-22*

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

## FOREWORD

This report was prepared by Communication and Navigation Laboratory, Wright Air Development Center, on equipment obtained through Contract No. AF 33(038)-11303 with Press Wireless Manufacturing Company, Incorporated. Work reported herein was accomplished under Research and Development Order No. 102-22, "Airborne Teletypewriter Equipment." Acknowledgement is made of the assistance for obtaining the datum used herein to personnel of the Test Branch, Components and Systems Laboratory, and to Coles Signal Laboratory, Red Bank, New Jersey, for assistance in obtaining the distortion factors of the equipment. Mr. William S. Dwinell served as project engineer.

## ABSTRACT

Laboratory acceptance tests were made on the samples of RF Oscillator O-(XA-5)/U, developed by Press Wireless Manufacturing Company, West Newton, Massachusetts.

An investigation was made of the performance of the O-(XA-5)/U when subjected to atmospheric service conditions, and data obtained to determine requirements fulfillment.

It is concluded that the RF Oscillator O-(XA-5)/U as developed by Press Wireless Manufacturing Company is satisfactory for use as an airborne exciter unit for a fr:quency shift keyed teletypewriter system.

## PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDING GENERAL:

for CHARLES U. BROMBACH
Colonel, USAF
Chief, Comm and Nav Laboratory
Directorate of Laboratories

## TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

## INTRODUCTION

During the early investigations performed concerning the possibility of utilizing teletypewriter equipments in aircraft, use of standard ground equipment indicated that operator skill determined, to a large extent, successful operation of a frequency shift keyed system. In order to alleviate this situation, and provide for equipment more suited for aircraft installation, development was initiated on units to replace the conventional equipments. One such development was for an exciter unit to replace Exciter Unit O-5/FR for airborne use with Radio Transmitting Set AN/ART-13.

Initial requirements for this unit, subsequently designated RF Oscillator O-(XA-5)/U, specified miniaturization of the O-5/FR, incorporation of two additional crystal channels (total of five in lieu of three), decreasing warm-up time necessary for frequency stabilization, from two hours to 15 minutes, and simplification of the operator tuning procedure by incorporating preset tuning mechanisms.

After considerable investigation by the contractor, it was determined unlikely that the frequency stability specified could be attained in the warm-up time specified, using the circuitry of the O-5/FR. As a result, the circuitry of the new equipment was changed so as to utilize the beat of two crystals, one pulled in accordance with the keying signals, rather than the beat of a crystal and a reactance tube controlled, variable frequency oscillator.

Frequency stability of the unit was specified such as to allow no more than twenty cycles drift in one hour nor more than fifty cycles drift in twenty-four hours. This stability was specified to be obtained in fifteen minutes under all service conditions. As the frequency recorded was constant after six hours of operation, a twenty-four hour test was not considered necessary inasmuch as special provisions were necessary for personnel to accomplish this test.

## SECTION I

## REPORT OF TESTS

RF Oscillator O-(XA-5)/U was subjected to a series of tests to determine compliance with the general requirements as specified in the purchase request, and to determine the over-all performance characteristics of the units. Tests were performed to determine (1) frequency stability under service conditions, (2) power output, (3) spurious radiation, (4) keying distortion, (5) warm-up time. The procedure for the tests, compilation of data, equipment utilized, and graphs of test results are found in Appendix A.

The units tested fulfilled all requirements with the exception of the power output. However, as the requirement incorporated a considerable safety margin, the output is adequate for use with Radio Transmitter AN/ART-13 in an airborne installation.

Warm-up time for the crystal oven was found to be within the specified time. Oven temperature was stabilized after fifteen minutes warm-up time from a storage temperature of -55°C.

Frequency stability was excellent. After warm-up, maximum drifts were noted as follows:

1. At room temperature, a frequency drift was ten cycles during an eight hour test run.

2. With a ranging temperature from -55°C to +55°C, frequency drift was 35 cycles in a four hour period.

3. With an ambient temperature of -55°C, frequency drift was 30 cycles in a 4.5 hour period.

4. With an ambient temperature of +55°C, frequency drift was 25 cycles in a 4 hour period.

The above drift measurements were taken using an output frequency of 2.5 mc. The most severe drift was 35 cycles during the ranging temperature check. With a variation of input power, during high altitude conditions, vibration, and shock, frequency stability was the same as found during the temperature runs.

The spurious frequency output was found to meet the requirements; the basic crystal frequencies were down at least 75 db, and the third harmonic of the beat frequency was down 32 db. Keying distortion was found to be of the order of 5% spacing bias, with a 3% over-all peak distortion. These values are within the acceptable range for this type equipment.

Construction of the units was found to be satisfactory, as no apparent damage resulted from the vibration and shock tests. Tests of the equipment during and following submission of the unit to vibration and shock showed no change in electrical characteristics.

## SECTION II

## CONCLUSIONS

Based upon the results of the tests performed, RF Oscillator O-(XA-5)/U fulfills the requirements as specified. The equipment is thought to be worthy of consideration for use in any instance wherein use of a crystal for each operating frequency can be reconciled by the frequency stability, fast warm-up, and ease of operation attained.

## APPENDIX A

## TEST AND RESULTS

1. <u>Tests:</u>

A. Frequency Stability:

(1) Voltage

(a) Normal
(b) ±10 percent

(2) Temperature

(a) Room
(b) -55°C through +55°C
(c) -55°C
(d) +55°C

(3) Altitude

(a) 40,000 feet, -55°C

(4) Vibration and Shock

B. Power Output

C. Distortion

2. Procedure:

A. The frequency stability of the RF Oscillator was determined by mixing the fundamental (2.5 mcs) of the unit and the twenty-fifth harmonic of the standard (100 KC) harmonic generator. The audio signal output of the Super-Pro receiver was then fed into an electronic frequency meter and recorded on an Esterline Angus recorder. The variation in the recorded frequency is the frequency drift.

(1) The above test was performed under the following temperature conditions:

(a) Room Temperature
(b) -55 to +55°C with 5°C temperature change every 10 minutes
(c) -55 ± 2°C
(d) +55 ± 2°C

B. Part A1(a) of the test procedure was repeated with the input power voltage varied ±10% from normal.

C. The RF oscillator was subjected to a temperature of -55 ± 2°C and a pressure equivalent to an altitude of 40,000 feet. After temperature stabilization was reached, the frequency drift of the RF oscillator was recorded.

D. The unit with shock mounts was vibrated with the frequency varying uniformly between 10 and 55 cycles per second and returning to 10 cycles per second in approximately 1 minute at an amplitude of 0.06 inch total excursion. Application of the vibration was for 90 minutes in each of the following directions:

(1) Horizontally, parallel to the major horizontal axis of the RF oscillator.
(2) Horizontally, at right angles to the major horizontal axis.
(3) Vertically.

E. The unit without shock mounts was subjected to 30 impact shocks of 30G's with each shock impulse having a time duration of 11 ± 1 milliseconds. The shock was applied in the following directions:

(1) Horizontally, parallel to the major horizontal axis, five shocks in each direction.
(2) Horizontally, at right angles to the major horizontal axis, five shocks in each direction.
(3) Vertically, five shocks in each direction.

F. The power output of the RF oscillator was checked at normal and ±10% off normal input power voltage by measuring the voltage across a 51.5 ohm non-inductive load.

G. The spurious frequencies were measured by a substitution method. The frequency to be measured was picked up on a receiver through a standard attenuator and the magnitude of the signal was matched by a signal from the standard signal generator.

3. Results:

(1) The maximum frequency drifts for various temperatures are:

| Graph No. | Freq. Drift (Cycles) | Temperature | Time of Test Run (Hours) |
|---|---|---|---|
| 1 | 10 | Room | 8 |
| 2 | 35 | -55 to +55°C | 4 |
| 3 | 30 | +55 ±2°C | 4.5 |
| 4 | 25 | -55 ±2°C | 3.9 |

(2) The maximum frequency drift of the RF oscillator was approximately 10 cycles for ±10% variations in input power and crystal heater voltages.

(3) At a pressure equivalent to an altitude of 40,000 feet and at a temperature of -55 ± 2°C, a frequency drift of approximately 30 cycles was recorded. (See Graph 5).

(4) With the sample vibrating as specified in part D of the test procedure, the frequency drift was found to be 20 cycles. (See Graph 6).

(5) After the unit was subject to the shock test as specified in part E of the test procedure, the recorded frequency drift was 10 cycles.

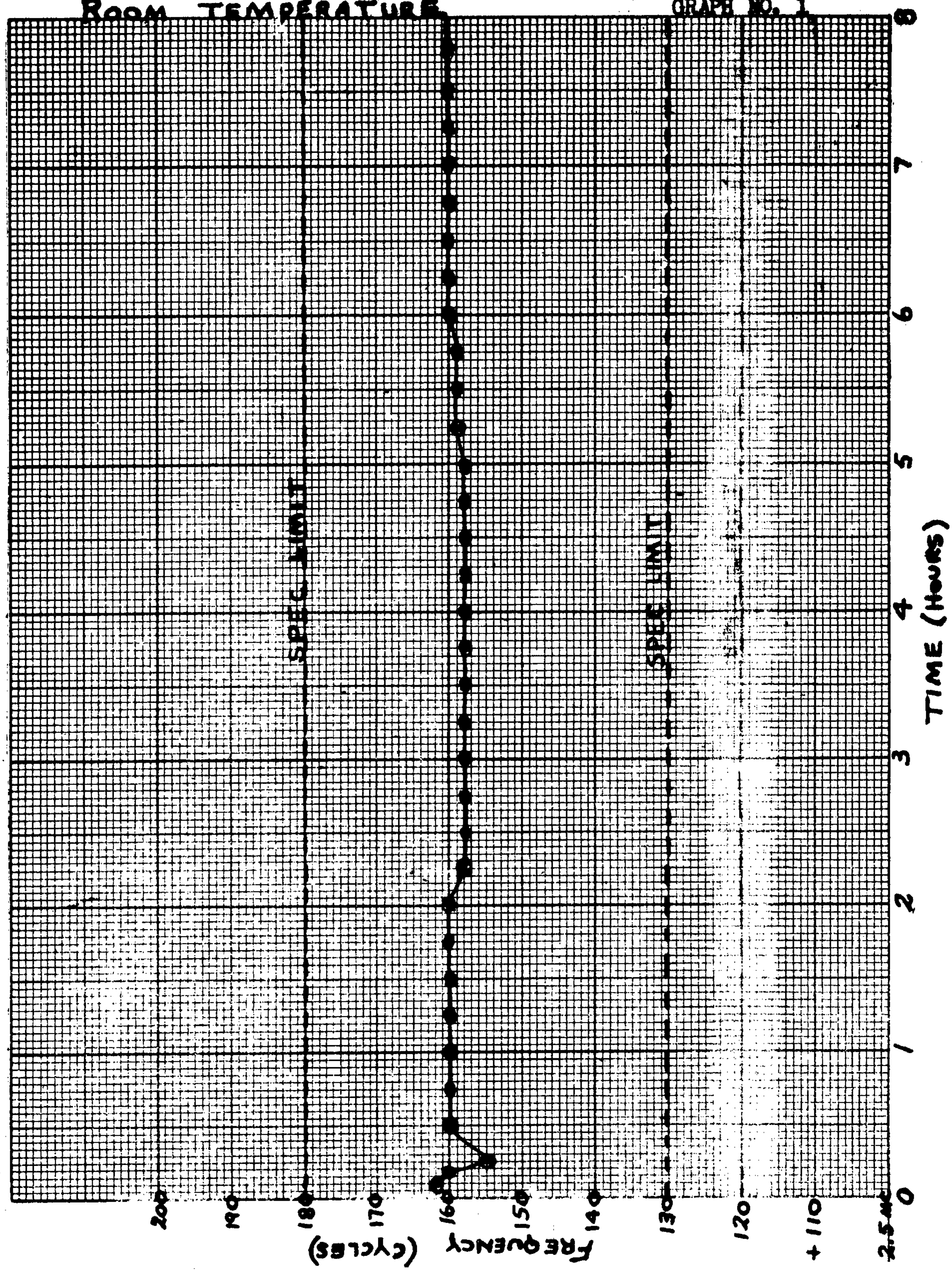
(6) The power outputs were 1.09, 1.83, and 2.57 watts for input voltages of 103.5, 115, and 125.4, respectively.

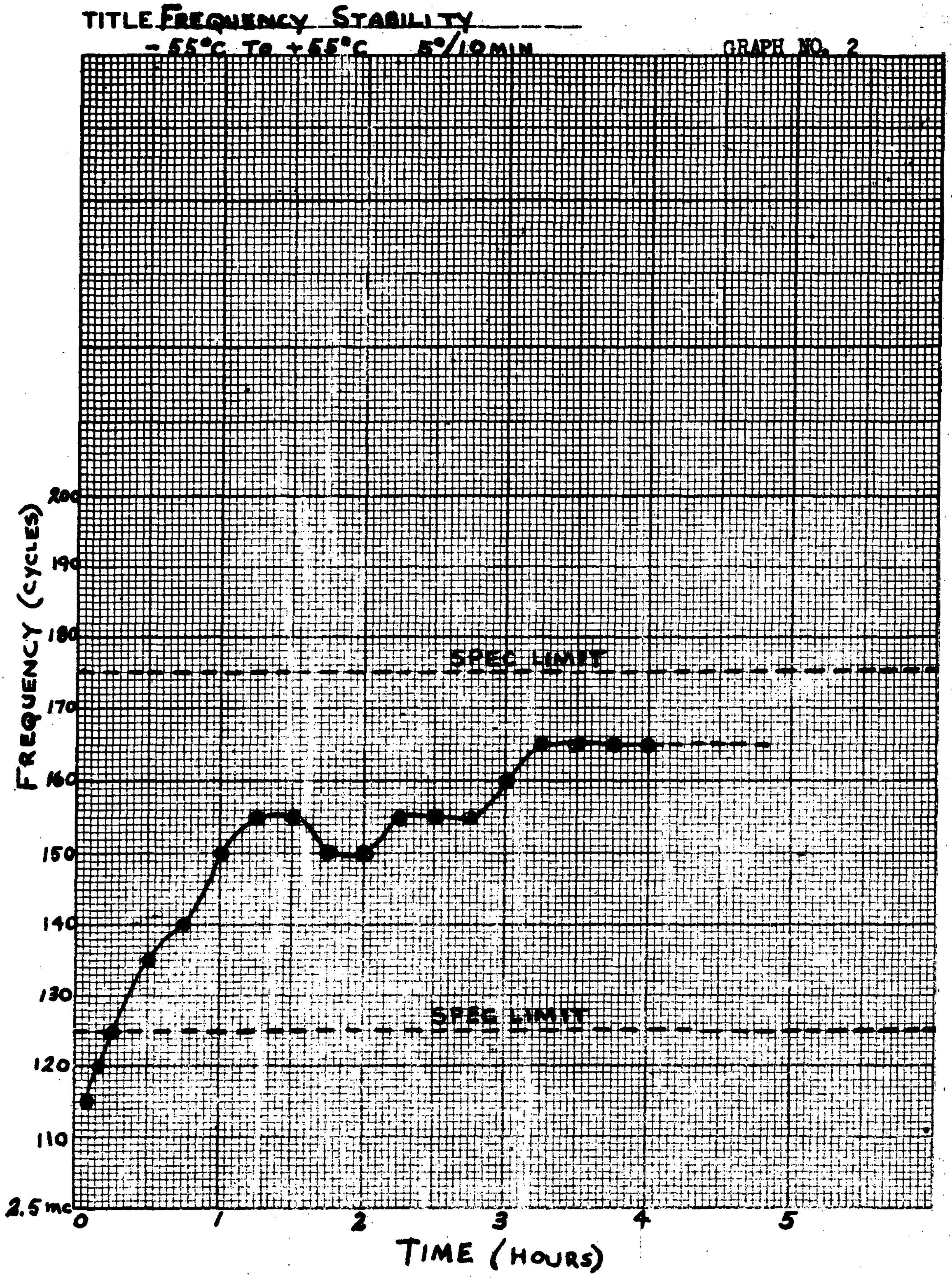
(7) The values of spurious frequencies are as follows: (See Graph 7).

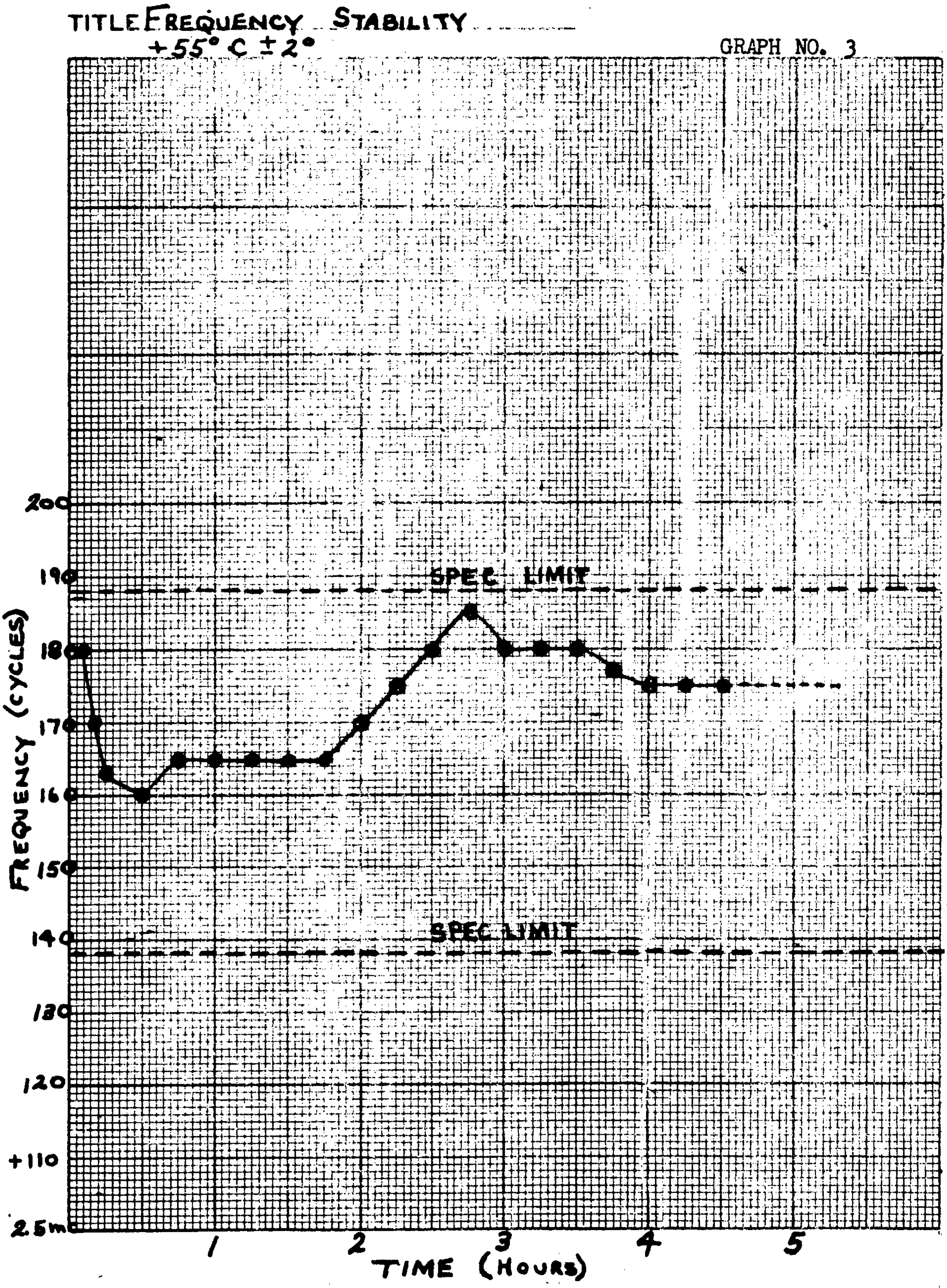
| Frequency | STD SIG Gen. Voltage | % of 2.5 mcs Output of XA-5 | DB |
|---|---|---|---|
| 2.5 | 1.45 X 1000 uv | — | — |
| 5.0 | .59 X 1000 | 40.6 | -7.8 |
| 6.25 | .36 X 100 | 2.48 | -32.1 |
| 7.5 | .25 X 100 | 1.72 | -35.3 |
| 8.75 | .14 X 100 | 0.965 | -40.3 |
| 10.0 | .2 X 100 | 1.38 | -37.2 |
| 9. | .2 X 1 | .0138 | -77.2 |
| 10.25 | negligible | — | -90 Approx. |

TITLE FREQUENCY STABILITY
ROOM TEMPERATURE

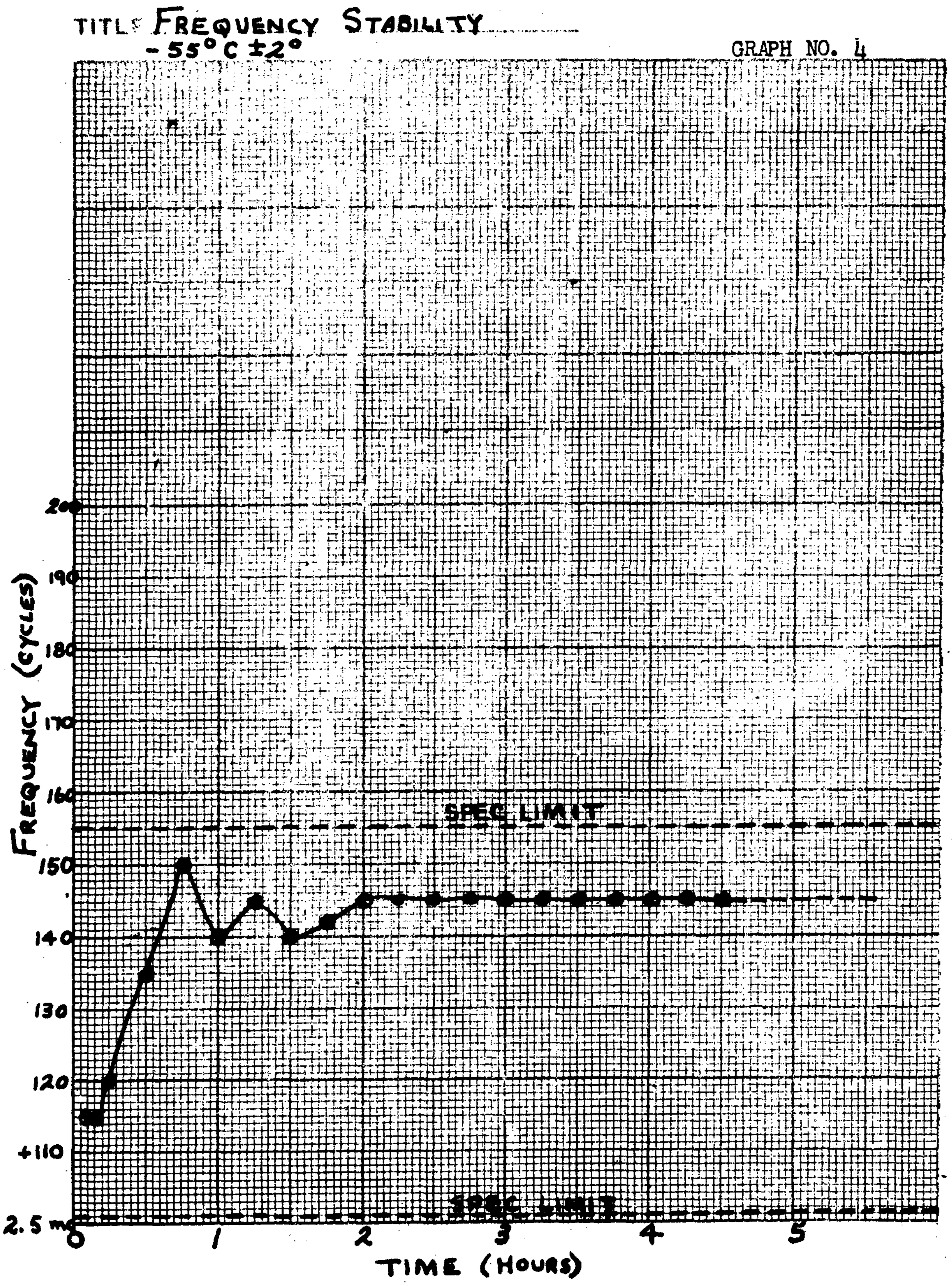
GRAPH NO. 1




TITLE FREQUENCY STABILITY
-55°C TO +55°C 5°/10MIN
GRAPH NO. 2
FREQUENCY (CYCLES)
200
190
180
170
160
150
140
130
120
110
2.5 mc
SPEC LIMIT
SPEC LIMIT
0
1
2
3
4
5
TIME (HOURS)



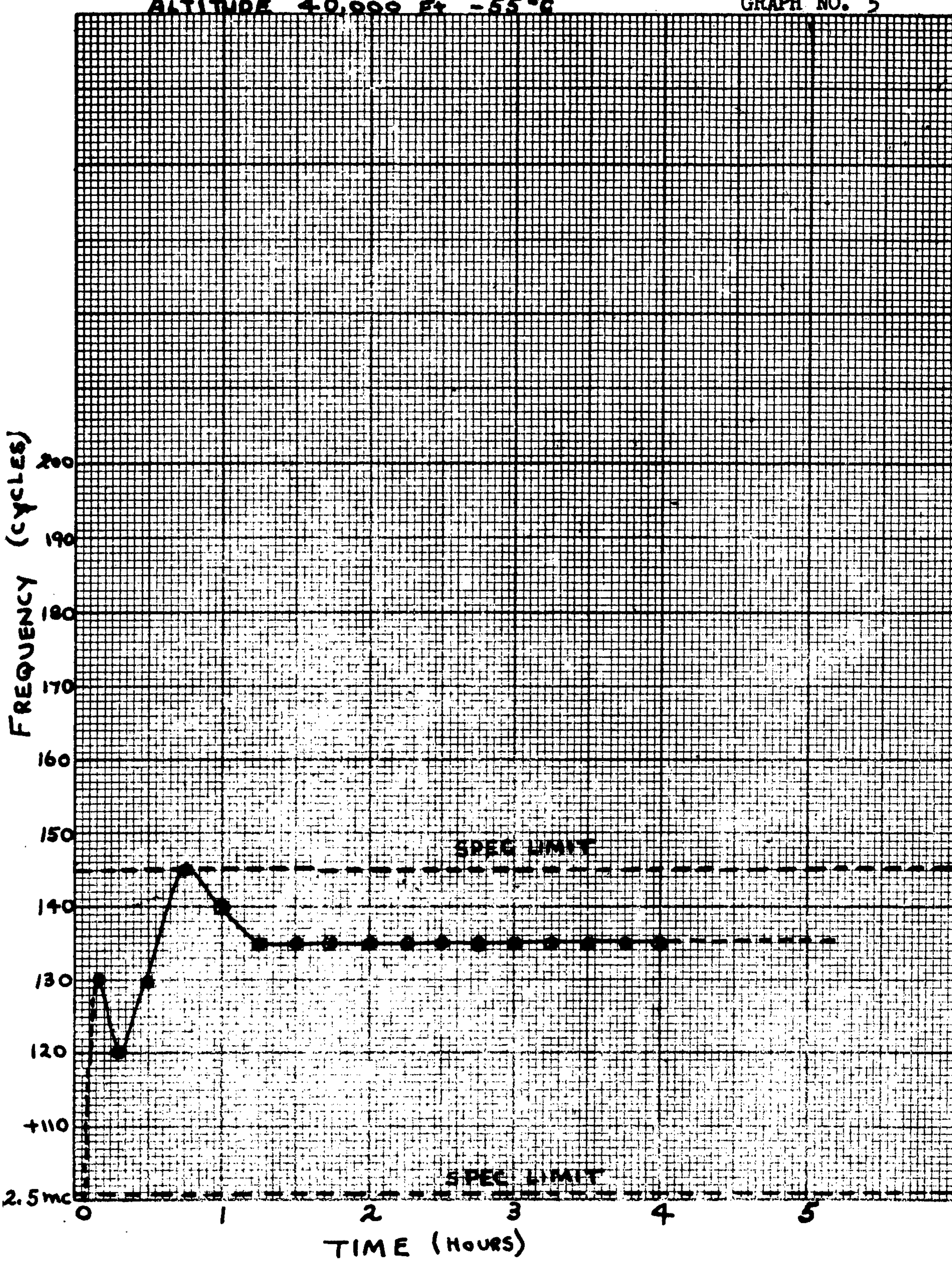
TITLE FREQUENCY STABILITY
+55° C ± 2°
GRAPH NO. 3
FREQUENCY (CYCLES)
200
190
180
170
160
150
140
130
120
+110
2.5mc
SPEC LIMIT
SPEC LIMIT
1
2
3
4
5
TIME (HOURS)

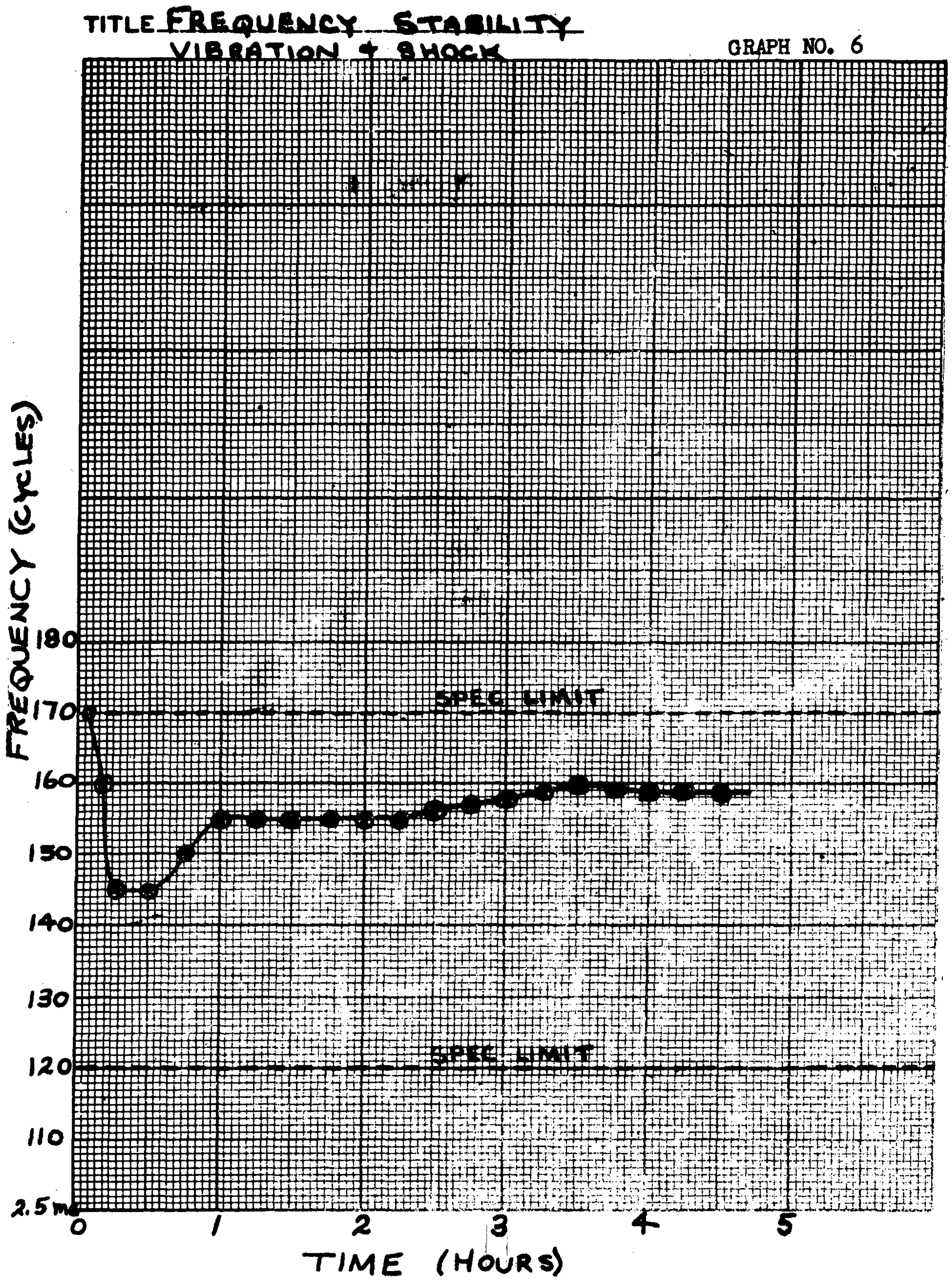

TITLE FREQUENCY STABILITY
-55° C ±2°
GRAPH NO. 4
FREQUENCY (CYCLES)
200
190
180
170
160
150
140
130
120
+110
2.5 mc
SPEC LIMIT
SPEC LIMIT
0
1
2
3
4
5
TIME (HOURS)

TITLE FREQUENCY STABILITY

ALTITUDE 40,000 Ft -55°C

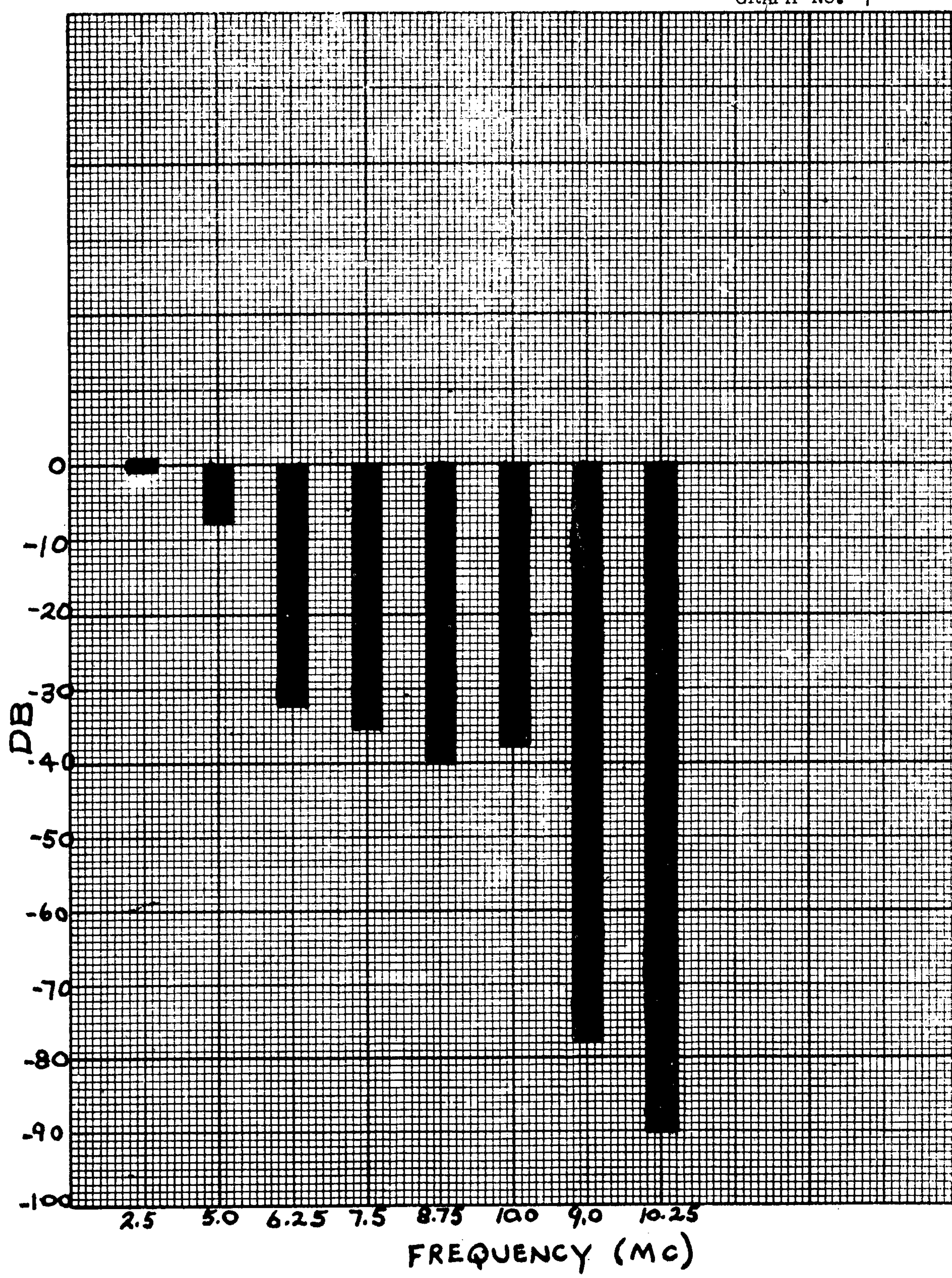
GRAPH NO. 5




TITLE FREQUENCY STABILITY
VIBRATION & SHOCK
GRAPH NO. 6
FREQUENCY (CYCLES)
180
170
160
150
140
130
120
110
2.5 mc
SPEC LIMIT
SPEC LIMIT
0
1
2
3
4
5
TIME (HOURS)

TITLE Spurious Frequencies

GRAPH NO. 7



DATA

FREQUENCY STABILITY - TEMPERATURE CONDITIONS

| Elasped Time | Frequency Deviation Cycles from Zero Beat Room Temperature(22°C) | Frequency Deviation Cycles from Zero Beat +55° ±2°C | -55°C | -55 to +55°C |
|---|---|---|---|---|
| 5 min | 162 | 180 | 115 | 115 |
| 10 min | 160 | 170 | 115 | 120 |
| 15 min | 155 | 163 | 120 | 125 |
| 30 min | 160 | 160 | 135 | 135 |
| 45 min | 160 | 165 | 150 | 140 |
| 1 Hour | 160 | 165 | 140 | 150 |
| 15 min | 160 | 165 | 145 | 155 |
| 30 min | 160 | 165 | 140 | 155 |
| 45 min | 160 | 165 | 142 | 150 |
| 2 Hours | 160 | 170 | 145 | 150 |
| 15 min | 158 | 175 | 145 | 155 |
| 30 min | 158 | 180 | 145 | 155 |
| 45 min | 158 | 185 | 145 | 155 |
| 3 Hours | 158 | 180 | 145 | 160 |
| 15 min | 158 | 180 | 145 | 165 |
| 30 min | 158 | 180 | 145 | 165 |
| 45 min | 158 | 177 | 145 | 165 |
| 4 Hours | 158 | 175 | 145 | 165 |
| 15 min | 158 | 175 | 145 | 165 |
| 30 min | 158 | 175 | | |
| 45 | 158 | 175 | | |
| 5 Hours | 158 | | | |
| 15 min | 159 | | | |
| 30 min | 159 | | | |
| 45 min | 159 | | | |
| 6 Hours | 160 | | | |
| 15 min | 160 | | | |
| 30 min | 160 | | | |
| 45 min | 160 | | | |
| 7 Hours | 160 | | | |
| 15 min | 160 | | | |
| 30 min | 160 | | | |
| 45 min | 160 | | | |
| 8 Hours | | | | |

## FREQUENCY STABILITY - ALTITUDE; MECHANICAL

| Elapsed Time | Frequency Deviation (Cycles) Altitude 40,000 feet -55°C | Frequency Deviation Cycles from Zero Beat Vibration | Shock |
|---|---|---|---|
| 5 min | 80 | 170 | 170 |
| 10 min | 130 | 160 | 160 |
| 15 min | 120 | 145 | 150 |
| 30 min | 130 | 145 | 150 |
| 45 min | 145 | 150 | 150 |
| 1 Hour | 140 | 155 | 155 |
| 15 min | 135 | 155 | 155 |
| 30 min | 135 | 155 | 155 |
| 45 min | 135 | 155 | 156 |
| 2 Hours | 135 | 155 | 158 |
| 15 min | 135 | 155 | 158 |
| 30 min | 135 | 156 | 155 |
| 45 min | 135 | 157 | 160 |
| 3 Hours | 135 | 158 | 155 |
| 15 min | 135 | 159 | 155 |
| 30 min | 135 | 160 | 155 |
| 45 min | 135 | 159 | 155 |
| 4 Hours | 135 | 159 | 160 |
| 15 min | 135 | 159 | 155 |
| 30 min | 135 | 159 | 160 |

## FREQUENCY STABILITY - INPUT POWER VARIATION

| Power Variation | | Frequency Deviation Cycles from Zero Beat |
|---|---|---|
| 24 VDC | 125 VAC | 155 |
| 24 VDC | 115 VAC | 160 |
| 24 VDC | 105 VAC | 160 |
| 26.5 VDC | 115 VAC | 160 |
| 26.5 VDC | 125 VAC | 160 |
| 29 VDC | 125 VAC | 160 |
| 29 VDC | 115 VAC | 160 |
| 29 VDC | 105 VAC | 165 |

## POWER OUTPUT

| Input Volts | Output Volts | Calc Watts $\frac{V^2}{R}$ R = 51.5 ohms |
|---|---|---|
| 103.5 VAC | 7.5 V RF | 1.09 |
| 115.0 VAC | 9.7 V RF | 1.83 |
| 126.5 VAC | 11.5 V RF | 2.57 |

## APPENDIX B

## THEORY OF OPERATION

General:

A block diagram of the RF Oscillator O-(XA-5)/U is shown in Figure 8. There are two crystal oscillators, V103 and V104, whose outputs are mixed in V105. The difference frequency is doubled by V106 and the output therefrom is fed to the final amplifier stage consisting of V107 and V108 in parallel. Reference Figure 9.

### a. The Selected Frequency Oscillator

V104 is essentially a Pierce type crystal oscillator. However, the crystal, one of Y101 to Y105, is connected from grid to ground rather than from grid to plate since the plate is bypassed to ground. The Frequency Selector Switch S106 selects one of the channels 1 to 5 which are controlled by the crystals Y101 to Y105 respectively. The crystals Y101 to Y105 may be of any frequency within the range 10.0 to 12.0 mc/s. The trimmers C131 to C135 are factory adjustments for setting the shunt capacity across the crystals to the value for which the crystals are calibrated (32 ±0.5 uuf).

### b. The Keyed Oscillator

V103 is the keyed oscillator. The circuit is similar to that of V104. However, the shunt capacity contributed by wiring and C107 and C108 is made larger than the corresponding capacity across Y101 to Y105. This increased capacity tends to lower the oscillator frequency slightly below the nominal value. But the capacity of C101 and C106, which is connected in series with Y106 to ground, tends to increase the oscillator frequency accurately to 9.000 mc. Switching additional capacity in parallel with C101 shifts the frequency downward, thus achieving the required frequency shift keying. If the shift selector switch for the frequency position in use is set on "284 cycles", then only C102 is switched by the keying relay K101. But with the corresponding shift selector switch (one of S101 to S105) on "850 cycles", the capacitors C104 and C105 are also switched by K101. The keying relay K101 is a special unit designed for high speed keying operation. It will operate satisfactorily up to speeds of 100 words per minute.

### c. Mixer

The signal from the 9.0 mc oscillator V103 is fed to grid 1 of the mixer V105 and that from the 10.0 to 12.0 mc oscillator V104, is fed to the other input grid of the mixer. The plate circuit of the mixer contains a two-section, low pass filter with a cut-off of about 4.0 mc, which prevents the oscillator signals from reaching the following stage V106. The desired output signal from the mixer is in the range 1.0 to 3.0 mc and is therefore passed by the mixer plate filter.

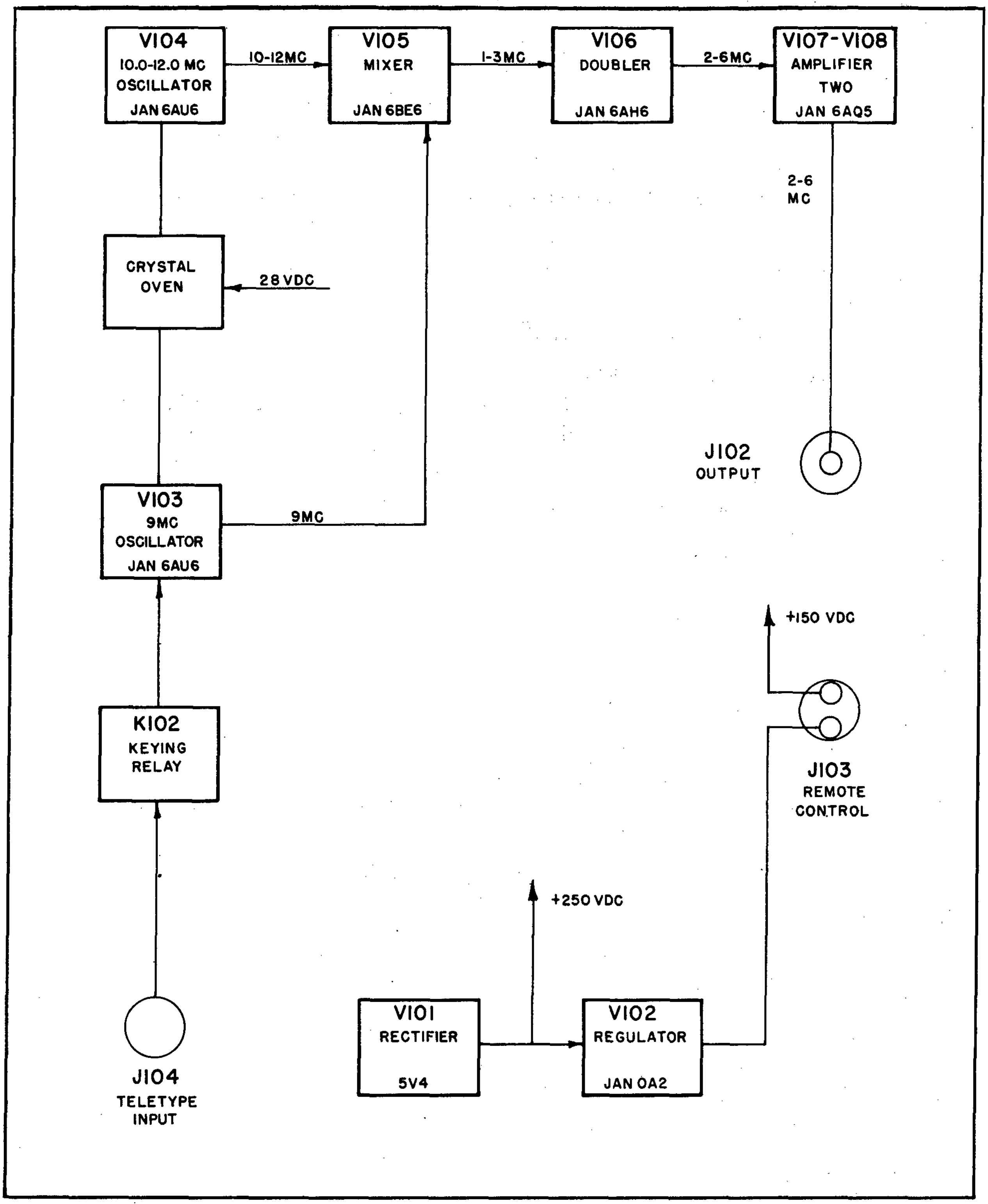


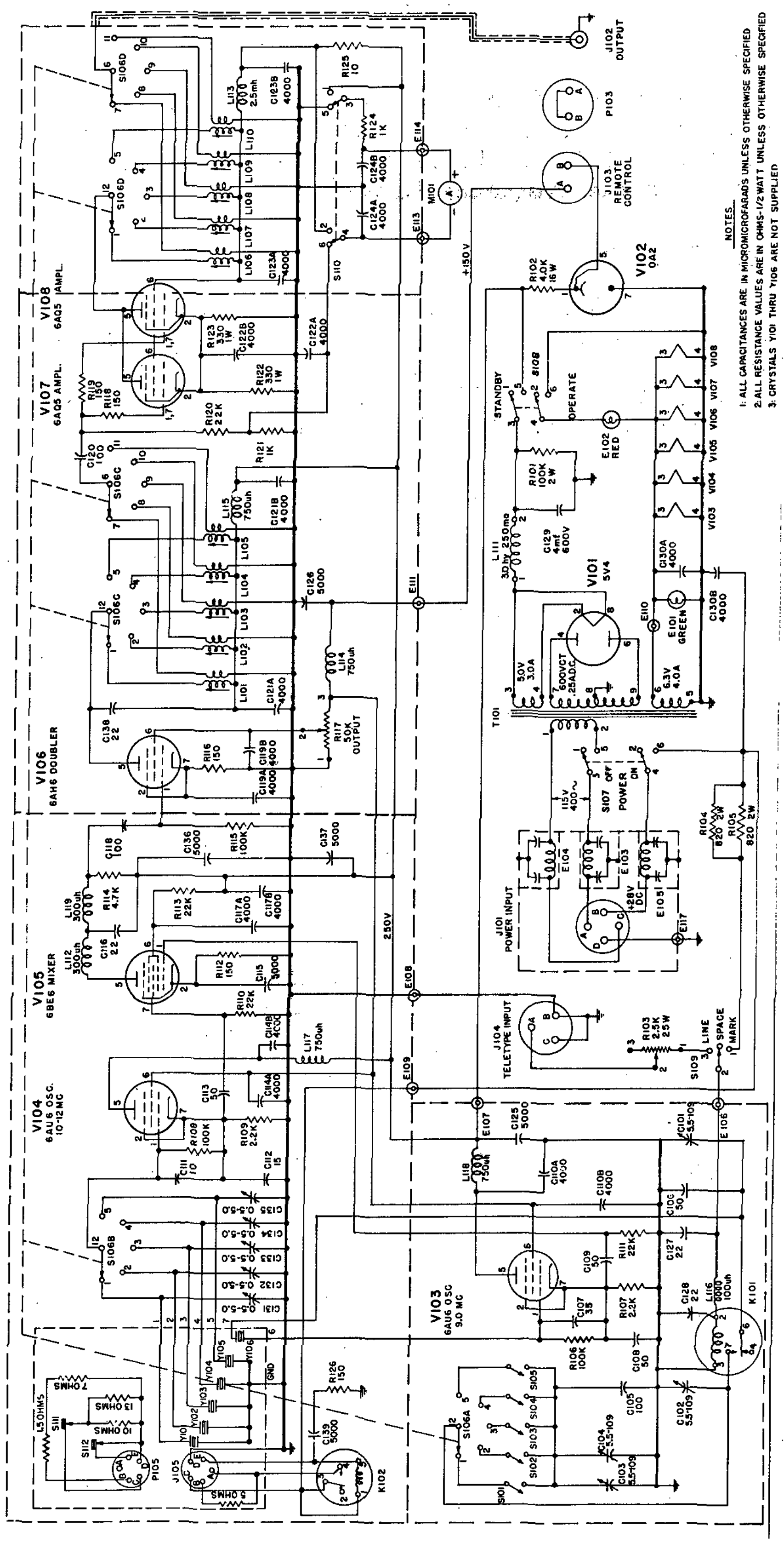

**Figure 8. R.F. Oscillator O-(XA-5)/U-Block Diagram**

d. Doubler

The output signal from the mixer plate filter is fed to the doubler V106. One tunable plate coil for each of the five preset frequencies is provided. One section, S106c of the Frequency Selector Switch, selects the appropriate coil for the frequency in use.

e. Final Amplifier

The final amplifier, consisting of V107 and V108 in parallel, is driven by the output from the doubler. The section S106d of the Frequency Selector Switch in the plate circuit, selects one of the coils L106 to L110 for the frequency in use. The switch S110 on the rear of the chassis allows the panel meter M101 to indicate either the "FINAL GRID" or "FINAL PLATE" current.



NOTES

1. ALL CAPACITANCES ARE IN MICROMICROFARADS UNLESS OTHERWISE SPECIFIED
2. ALL RESISTANCE VALUES ARE IN OHMS-1/2 WATT UNLESS OTHERWISE SPECIFIED
3. CRYSTALS Y101 THRU Y106 ARE NOT SUPPLIED

Figure 9. R.F. Oscillator O-(XA-5)/U Schematic Diagram

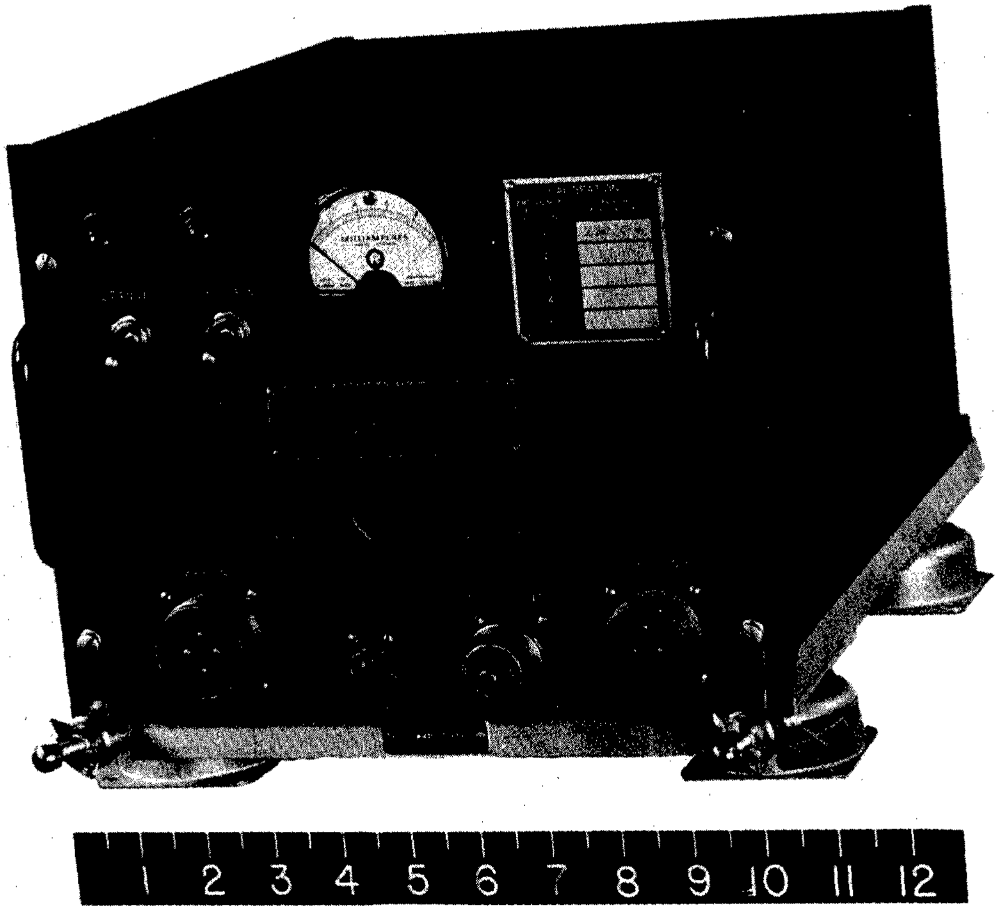



**Figure 10**
RF OSCILLATOR O-(XA-5)/U DIAGONAL FRONT VIEW

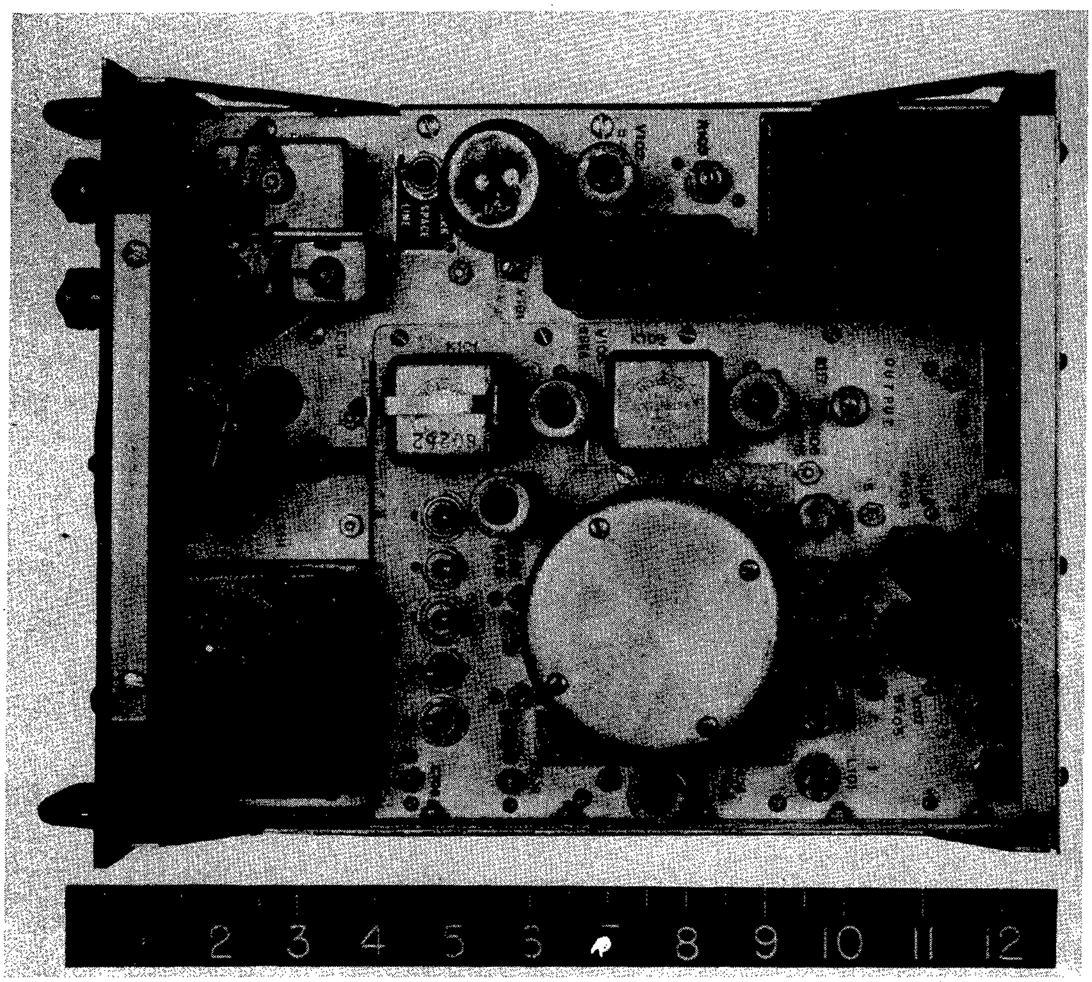


**Figure 11**
RF OSCILLATOR O-(XA-5)/U INTERIOR TOP VIEW

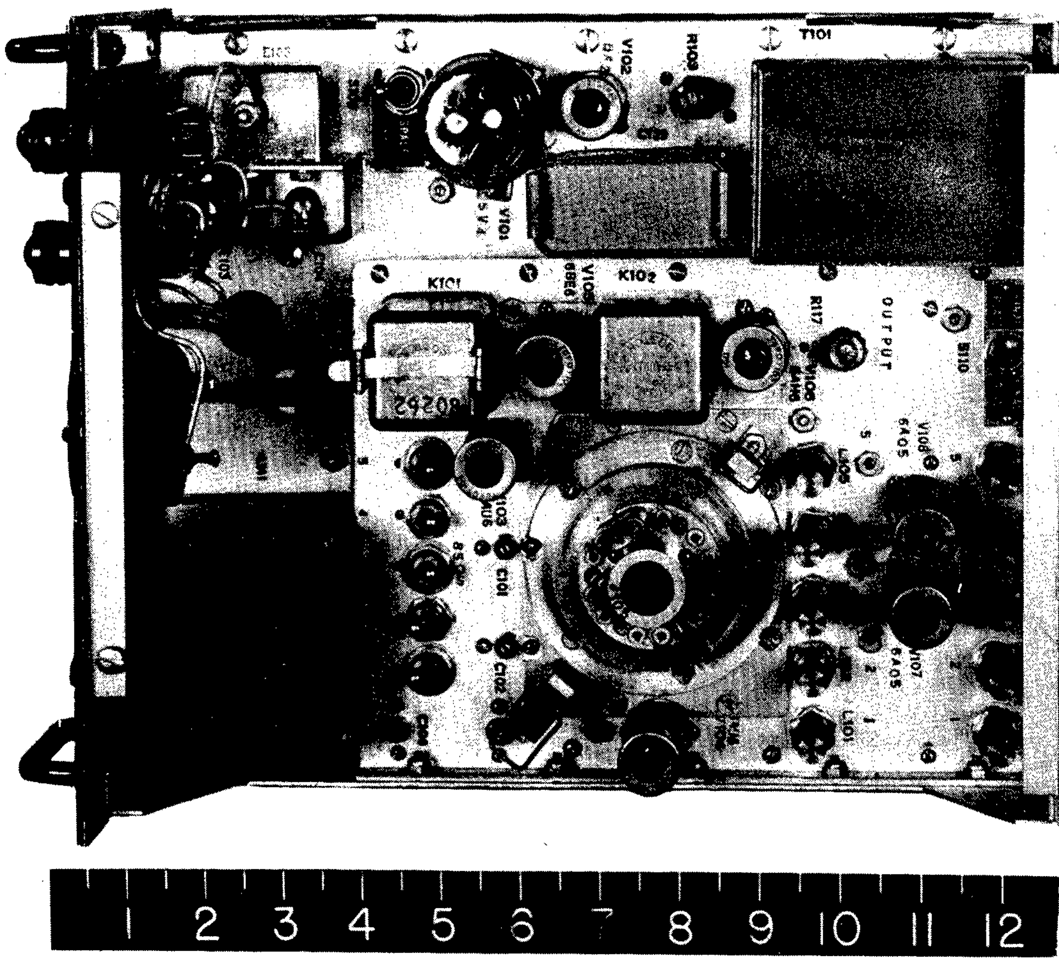



**Figure 12**
RF OSCILLATOR O-(XA-5)/U INTERIOR TOP VIEW (OVEN OPEN)

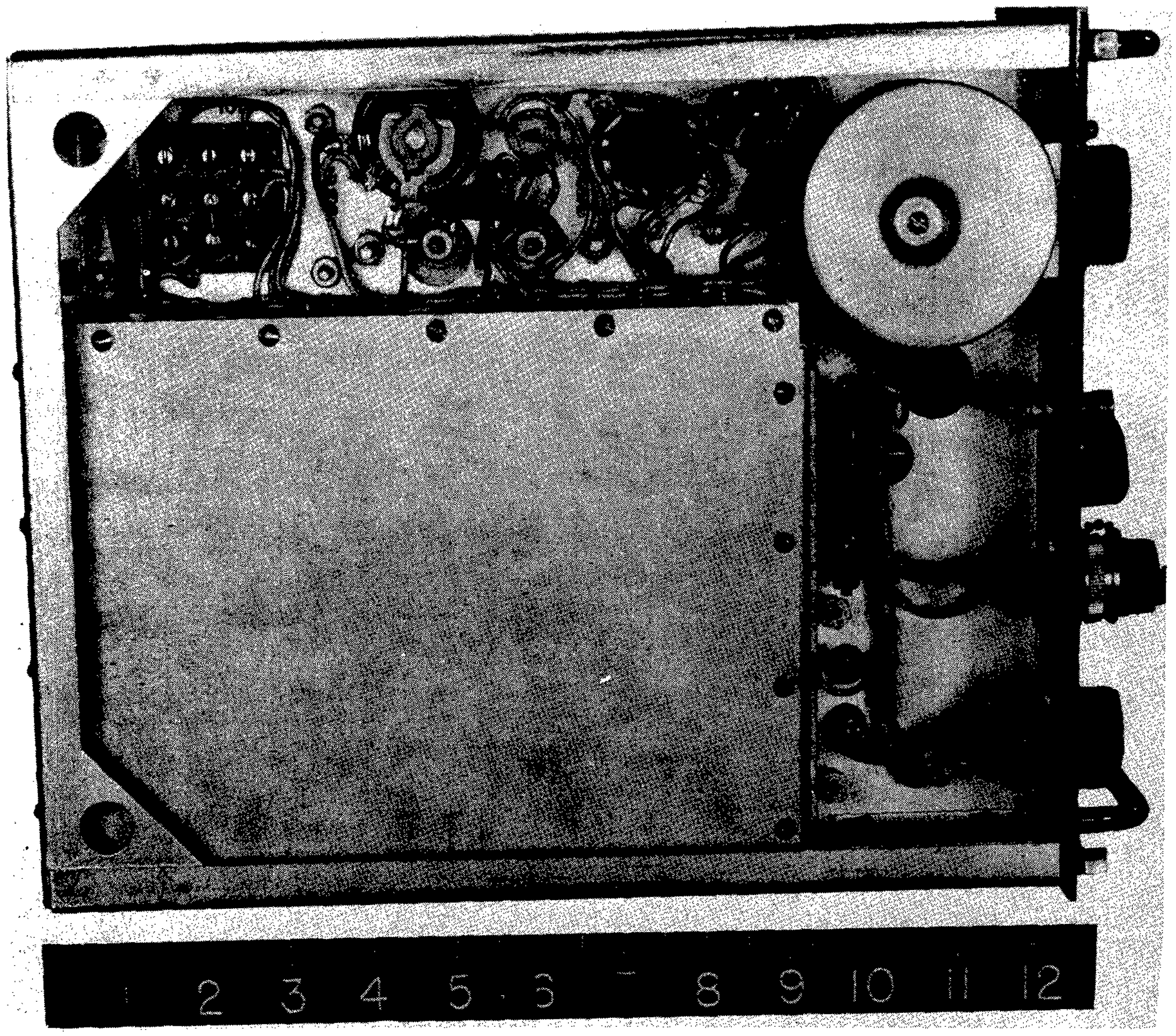



**Figure 13**
RF OSCILLATOR O-(XA-5)/U INTERIOR BOTTOM VIEW

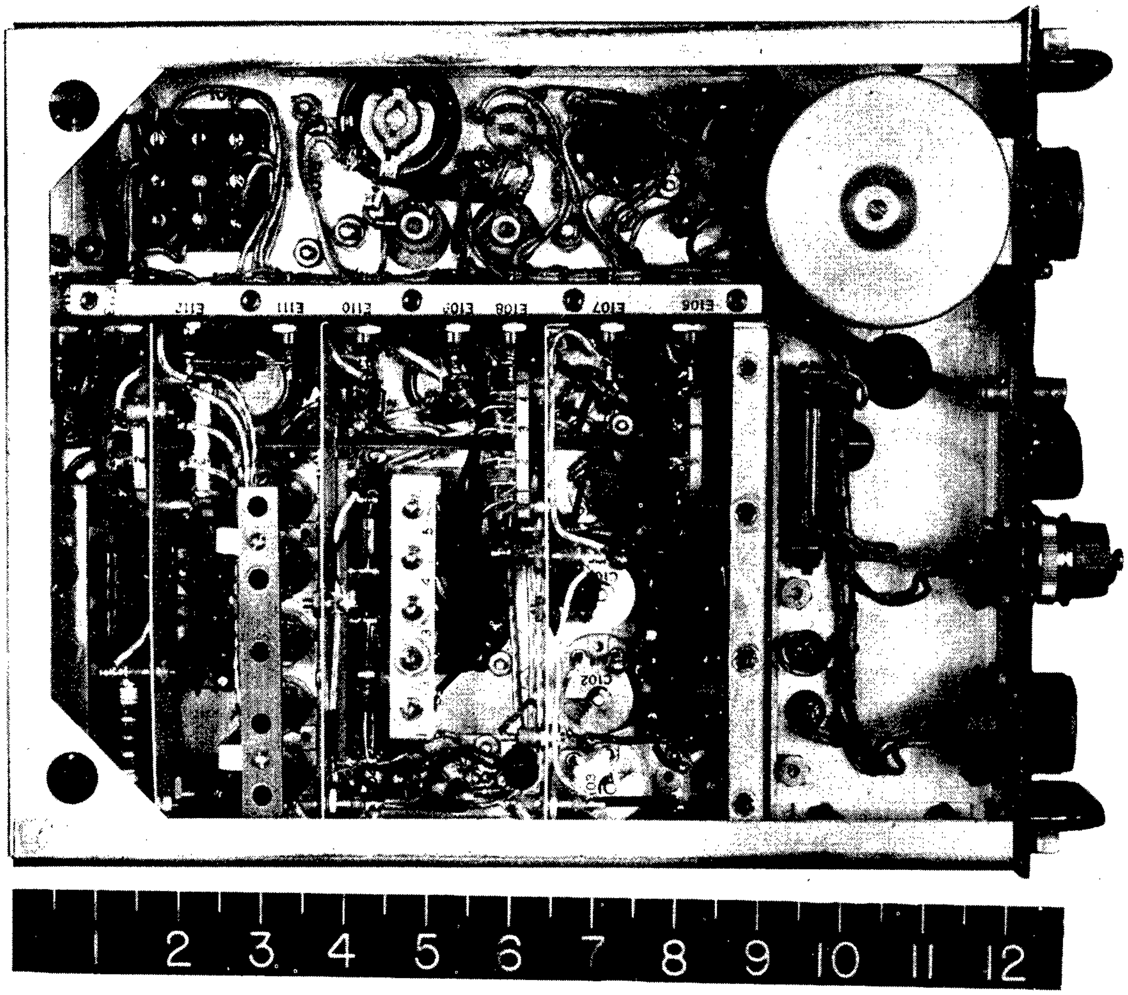



**Figure 14**
RF OSCILLATOR O-(XA-5)/U INTERIOR BOTTOM VIEW (SHIELD REMOVED)

DISTRIBUTION LIST FOR WADC TECHNICAL REPORT 52-239

| Cys | Activities at W-PAFB |
|---|---|
| 2 | DSC-SA |
| 2 | WCOWP (For Rand Corp.) |
| 4 | BAGR-CD, Mrs. D. Martin |
| 2 | WCAPP |

Dept of Defense Activities Other Than Those at W-PAFB

Air Force

1 Director of Research and Development
Headquarters, USAF
Washington 25, D. C.

1 Commanding General
Air Research and Development Command
ATTN: RDOL
P. O. Box 1395
Baltimore 1, Maryland

1 Commanding General
Rome Air Development Center
ATTN: ENR
Griffiss Air Force Base
Rome, New York

1 Commanding General
Air Force Cambridge Research Center
ATTN: ERR
230 Albany Street
Cambridge 39, Massachusetts

1 Washington AF Dev Field Office
Room 4945, Main Navy Bldg.
ATTN: Lt Colonel H. A. Orban
Washington 25, D. C.

1 AF Development Field Representative
Naval Research Laboratory
ATTN: Major Edgar Van Rosen
Washington 25, D. C.

| Cys | Activities |
|---|---|

1 Commanding General
Air Proving Ground Command
ATTN: Class. Tech. Data Br.,D/OI
Eglin Air Force Base, Florida

1 Director
Air University Library
Maxwell Air Force Base, Alabama

1 Director of Communications and Electronics
Air Defense Command
Ent Air Force Base
ATTN: AC&W Coordinating Division
Colorado Springs, Colorado

1 Commanding General
Strategic Air Command
ATTN: Operations Analysis Office
Offutt Air Force Base, Nebraska

Navy

Chief of Naval Research
Department of the Navy
Washington 25, D. C.
6 ATTN: Planning Div., Code N-482
1 ATTN: Elec. Section, Code 427

1 Chief of Naval Operations
Department of the Navy
ATTN: OP-42-B2
Washington 25, D. C.

1 Chief, Bureau of Ships
Department of the Navy
ATTN: Technical Data Section
Washington 25, D. C.

1 Director
U. S. Naval Research Laboratory
ATTN: Technical Data Section
Washington 25, D. C.

DISTRIBUTION LIST FOR WADC TECHNICAL REPORT 52-239

| Cys | Activities |
|---|---|
| 1 | CO & Director<br>U. S. Navy Electronics Laboratory<br>San Diego 52, California |
| 1 | Commander<br>U. S. Naval Air Development Center<br>ATTN: Electronics Laboratory<br>Johnsville, Pennsylvania |

Army

| | |
|---|---|
| 2 | Commanding Officer<br>Signal Corps Eng Laboratory<br>ATTN: Technical Reports Library<br>Fort Monmouth, New Jersey |
| 1 | OCSigO (SIGGD)<br>Engineering & Technical Division<br>Washington 25, D. C. |

Research and Development Board

| | |
|---|---|
| 2 | Research and Development Board<br>Library Branch, Info. Offices<br>Rm 3D1041<br>The Pentagon<br>Washington 25, D. C. |

Organization

| | |
|---|---|
| 1 | Press Wireless Manufacturing Company, Inc.<br>ATTN: Mr. N. F. Hoard<br>West Newton 65, Massachusetts |

AIR FORCE

| Cys | Activities |
|---|---|
| 1 | Commander<br>Military Air Transport Service<br>Andrews AF Base<br>Washington 25, D. C. |
| 1 | Chief, Air Weather Service<br>Andrews AF Base<br>Washington 25, D. C. |
| 1 | Joint Tactical Air Support Board<br>Fort Bragg, North Carolina<br>ATTN: Dept of Equipment |